Vertical installation of an elongated process unit

This invention relates to a method for installation of an elongate process unit on the seabed, said process unit having a first process unit end and a second process unit end. A method of retrieving said process unit from the seabed is also provided. Further, this invention relates to a receptor apparatus for use in a process unit handling operation.

Background of the invention

Since the installation or retrieval of a process unit, such as a separator, can become a part of the IMR-scheme for a field, it is important that this operation can be done efficiently with a minimum of down time. There is reason to believe that the maximum allowable operational sea-state for a horizontal deployment will be somewhat limited especially for operations from a monohull.

Prior art

US 4.676.696 (Laursen) relates to an apparatus for securing a flowline to a structure near the seabed, comprising a vertically oriented guide funnel placed atop a guide tube that is provided with a helical shoulder cooperating with an alignment key mounted on the flowline. During installation, the flowline is stabbed into the guide funnel and guide tube thereby causing the alignment key to slide along the shoulder until a pair of hinge pins mounted on the flowline have entered into a pair of slots in the wall of the guide tube. Subsequently, the flowline is hinged down to a horizontal position.

US 4.671.702 (Langner) relates to a method and apparatus for connecting a flowline to a subsea structure. A riser and flowline connection tool are deployed downwardly to the subsea structure and a flowline terminal head, which is at the end of the flowline, is pulled to the flowline connection tool by means of a pullcable. Then the flowline terminal head is secured to the subsea structure and the flowline connection tool is recovered to the surface. The flowline terminal head consists of a connector hub with clamping surface to which the flowline is welded, and a flexible carrier pipe of interlocking metallic rings into which the end of the flowline is inserted. The carrier pipe limits the curvature of the flowline as the terminal head is bent into alignment with

a flowline receptacle of the subsea structure. The flowline terminal head may include buoyant encircling rings which keep it free of difficult terrain in the vicinity of the subsea structure.

US 4.277.202 (Archambaud et al.) relates to a method and an apparatus for deploying and connecting an end of an underwater flowline to a connecting sleeve.

US 4.877.356 (Bontenbal) concerns a method and an apparatus for stabbing a flowline into a guide tube near the waterbottom and subsequently hinging over the flowline to a horizontal position. The connection operation is facilitated by a vertically oriented guide tube having along the inner wall thereof a pair of parallel slots which provide at the lower ends thereof pivot supports on which a pair of pivots which are mounted near the lower end of the flowline land during the stab in procedure. Deflectors are provided for deflecting a lower portion of the flowline while the pivots are lowered through the slots so as to induce the flowline to obtain a curved shape into a predetermined direction before the pivots land onto the pivot supports.

US 4.676.696 and US 4.717.287 (Laursen) both relate to an apparatus for securing a flowline to a structure near the seabed comprises a vertically oriented guide funnel placed atop a guide tube that is provided with a helical shoulder cooperating with an alignment key mounted on the flowline. During installation the flowline is stabbed into the guide funnel and guide tube thereby causing the alignment key to slide along the shoulder until a pair of hinge pins mounted on the flowline have entered into a pair of slots in the wall of the guide tube. Subsequently the flowline is hinged down to a horizontal position.

The above documents all describe methods and apparatuses for deploying flowlines or risers, whereas the methods and apparatus according to this invention relates to handling process units, in particular elongate process equipment such as separators, heat exchangers, containers, pumps, vessels, tanks or the like. The receptor apparatuses according to the above documents are all arranged for receiving an end of a flowline section while deploying a flowline on or near the seabed. Thus, they are not constructed for receiving the much larger load from process equipment.

On the other hand, the receptor apparatus according to this invention is designed for receiving such process units, e.g., separators, heat exchangers, containers

or the like, in particular elongate process units, and the load such process units exert on the receptor apparatus.

Short summary of the invention

This invention provides a method for installation of an elongate process unit on the seabed, in which said process unit has a first process unit end and a second process unit end. Said method is characterized in that it comprises the following steps.

a) preparing and moving said process unit to a position in which it is ready for being launched from a vessel and lowered through the sea with its longitudinal axis in a generally vertical orientation;

b) launching said process unit from said vessel;

c) lowering said process unit through the sea surface, the splash zone and further down to a deployment site on the seabed;

d) after said process unit lowering step c), entering said first process unit end into a receptor device for said first process unit end, so as to temporarily form a lower end of said first process unit end, the receptor device being located on the seabed or on a module foundation for said process unit at the seabed;

e) completing said process unit entry in said receptor device and retaining said first process unit end in place in said receptor device; and

f) lowering said second process unit end so as to bring the process unit (4) to a generally horizontal orientation on the seabed or said module foundation for said process unit, said first process unit end remaining supported by said receptor device, so as to form a fulcrum for said first process unit end, thus facilitating lowering of said second process unit end, and

g) deploying said process unit at the deployment site.

Furthermore, this invention provides a method of retrieving an elongate process unit from the seabed, in which said process unit has a first process unit end and a second process unit end. Said method is characterized in that it comprises the following steps:

a) preparing said process unit for removal from a deployment site;

b) lifting said second process unit end from the seabed or from on a module foundation for said process unit, said first process unit end being retained in a receptor device, thus temporarily forming a lower end of said first process unit end, and so as to bring the longitudinal axis of said process unit to a generally vertical orientation; said first process unit end of said process unit and said receptor device forming a fulcrum for said first process unit end, thus facilitating lifting of said second process unit end;

c) disengaging said first process unit end from said receptor device;

d) hauling said process unit from said deployment site at the seabed, up through the sea, the splash zone and the sea surface to a vessel;

e) bringing said process unit aboard said vessel, and

g) preparing and moving said process unit to a generally horizontal position onboard said vessel, in which it is sea-fastened and ready for being transported on said vessel.

Moreover, this invention provides a receptor apparatus for use in a process unit handling operation, in which the process unit to be handled comprises a first process unit end and a second process unit end. Said receptor apparatus is characterized in that it comprises a receptor device arranged for receiving and engaging a first process unit end, and further arranged for receiving and supporting the load of said process unit, Said receptor device is arranged for receiving and engaging said first process unit end, and said receptor device is further arranged for retaining said first process unit end in position in said receptor device so as to provide a fulcrum for said first process unit end during handling of said second process unit end.

More features and advantages of said method for lowering and deploying said process unit, of said method for retrieving said process unit, and of said receptor apparatus according to the invention appear from the respective, accompanying dependent claims.

Short description of the drawings

The following drawings serves to illustrate some embodiments according to the invention. The drawings are not made to scale.

Fig.1a is a schematic sectional side view of a lower portion of the process unit to be lowered and introduced into a receptor according to the invention.

Fig. 1b is a corresponding schematic sectional side view of a lower portion of the process unit which has been lowered into a position in the receptor device according to the invention, and now could be further arranged onto the module foundation of the desired deployment site.

Fig. 2a is a schematic top view of a vessel from which the process unit installation operation according to one embodiment of the inventtion will take place. The process unit has been positioned on the vessel deck in a position to be launched.

Fig. 2b is a schematic and partly sectional side view of the process unit being launched over a vessel stern roller of the vessel.

Fig. 2c shows a schematic and partly sectional view of the process unit ready to be lowered into the receptor device at the deployment site.

Fig. 2d shows a schematic and partly sectional view similar to fig. 2c of the process unit in which process unit entry into the receptor device has been completed, and now being ready to be further lowered onto the module foundation of the deployment site.

Fig. 2e shows a schematic and partly sectional view similar to figs. 2c-2d of the process unit being deployed onto the module foundation of the deployment site.

Fig. 2f shows a schematic and cross sectional view of the process unit through line A-A shown in fig. 2e.

Fig. 3a is a schematic side view of a further embodiment of the invention in which the process unit is raised into a vertical position on board the deployment vessel. A receptor device is utilized for keeping control on the first process unit end while lifting the other process unit end, so as to prepare the launching step of the process unit installation operation. An important advantage of this embodiment of the invention is better control the process unit movements during the lifting step.

Fig. 3b is a schematic and cross sectional view of the process unit shown in fig. 3a, taken along line A-A shown in fig. 3a.

Fig. 3c is a schematic side view similar to fig. 3a, in which the process unit has been raised to an upright position on the receptor device.

Fig 3d is a schematic side view similar to fig. 3a and 3b, in which the first process unit end has been lifted from the receptor device.

Fig. 4a-f shows schematic and partly sectional views of several lowering and deployment stages of the process unit installation operation according to the second embodiment of the invention, similar to fig. 2a-2f. The process unit is positioned onto the receptor device similarly to figs. 2a-2f, but in this embodiment, two shafts are provided which are located opposed to each other at the first process unit end. Each shaft is introduced into a guide in a bracket so as to form support bearings for the process unit in the receptor device.

Fig. 5 is a schematic and side view similar to fig. 3a-3d, in which the first process unit end supported by a receptor device arrangement as indicated in figs. 4a-4f, and in which lifting of the second process unit end so as to prepare the launching step of the process unit installation operation.

Fig. 6a is a schematic and side view of a process unit, in an embodiment according to the invention in which the framework on the first process unit end includes two mating pins located diametrically opposed to each other and protruding outwards from the side wall of the process unit. The two mating pins are each retained in a receptor bracket with a guide for the mating pin.

Fig. 6b is a schematic and cross sectional view of the process unit shown in fig. 6a, taken along line A-A.

Fig. 6c is a schematic top view of the process unit shown in figs. 6a-6b.

The invention will now be described in more detail, with reference to the accompanying drawings. The drawings should not be interpreted as limiting for the scope of the invention, which should be limited by the accompanying claims only.

Description of the preferred embodiments of the invention

Reference is made to figs. 2a-f, and to figs. 4a-f, in which a method is illustrated for lowering and deploying an elongate process unit 4 having a first process unit end 4a and a second process unit end 4b on the seabed. Said elongate process unit 4

may be any process equipment, such as a pump, a tank, a vessel, a container, a heat exchanger or a separator, e.g., a horizontal gravitational separator. The longitudinal length L of said process unit 4 is generally larger than its cross sectional length, or width, W.

Conducting the lowering and deploying operation with said elongate process unit arranged in a generally vertical or upright manner is a central feature of the invention.

A general embodiment of the process unit lowering and deploying method will now be described.

a) Said process unit 4 is prepared and moved to a position in which it is ready for being launched from a vessel 24 and lowered through the sea with its longitudinal axis in a generally vertical orientation.

b) Said process unit 4 is launched from said vessel 24.

c) Said process unit 4 is lowered into the sea through the sea surface, the splash zone and further down to a deployment site at the seabed.

d) After said process unit lowering step c), entering said first process unit end 4a into a receptor device 1 for said first process unit end 4a, so as to temporarily form a lower end of said first process unit end 4a. Said receptor device 1 may be located on the seabed or on a module foundation 12 for said process unit 4 at the seabed.

e) Then said process unit entry in said receptor device 1 is completed. Said first process unit end 4a of said process unit 4 is retained in place in said receptor device 1.

f) Said second process unit end 4b is then lowered so as to bring the process unit 4 to a generally horizontal orientation on the seabed or on said module foundation 12 for said process unit 4, said first process unit end 4a remaining supported by said receptor device 1, so as to form a fulcrum for said first process unit end 4a, thus facilitating lowering of said second process unit end 4b.

g) Said process unit 4 is deployed at the deployment site.

Said method may also include the step of landing said process unit 4 onto the vessel 24, e.g. onto the deck 14 of the vessel 24 or onto a transport frame 13, and transporting said process unit 4 to an offshore deployment site.

Said process unit 4 may include one or more, preferably two, launch beams 5 for facilitating generally horizontal movement of said process unit 4 and for providing support for said process unit 4 on said supporting arrangement 12a, or a process subsea skid 23, or on a transport frame 13.

For transport of said process unit 4 to the deployment site, said process unit 4 may for example be arranged on said launch beams 5 or on a transport frame 13. In the former case, said process unit 4 is moved from said transport frame 13 to a vessel deck 14 on said vessel 24 when preparing said process unit 4 for launch into the sea. When preparing said process unit 4 for lift into the sea by crane, said process unit 4, which may be resting on said transport frame 13, is moved to said vessel deck 14.

During the whole handling process, keeping control of said process unit 4 is very important. Control of said process unit 4 may be kept by means of a vessel wire system 36. Said vessel wire system includes a deployment crane wire 19 or a lowering wire 19 extending from said vessel crane or vessel winch 31 on said vessel 24 to said second process unit end 4b.

When preparing said process unit 4 for launch into the sea, said process unit 4 may be moved and guided towards the stern end of said vessel 24. Said first process unit end 4a may face said stern end of said vessel 24, so that said first process unit end 4a can be launched into the sea first. Launch of said process unit 4 may take place over a stern roller 29 located at said stern end of said vessel 24.

Said wire system 36 on said vessel 24 may include one or more, preferably two launch wires 22, each extending from said vessel crane or vessel winch 31 via a snatch block 25 or similar for each launch wire 22 to an attachment location on said vessel. Said snatch block 25 is preferably being located at the stern end of said vessel 24. Further, said wire system 36 on said vessel 24 may include a launch control-wire bridle 20 retaining said process unit 4 to a heave compensator 37. For lowering of said process unit 4, a lowering wire 19 attached to said vessel crane or vessel winch 31 and extending to said second process unit end 4b of said process unit 4 may also be included.

During preparation of said process unit 4 for launch into the sea from said transport frame 13 on said vessel deck 14 by means of lowering wire 19, said process unit 4 may be brought to a generally vertical position by lifting said second process unit end 4b, then disengaging said first process unit end 4a, hauling said process unit 4 from said transport frame 13, and bringing it into the sea.

When lowering said process unit 4, said vessel 24 is positioned generally above said receptor device 1 in the sea, and then said process unit 4 is lowered in the sea with its longitudinal axis in a generally vertical orientation down to said receptor device 1.

When said process unit 4 has been lowered to the deployment site at the seabed, said process unit 4 may be guided to said receptor device 1 before entering said first process unit end 4a of said process unit 4 into said receptor device 1.

A framework 34 including one or more process unit mating pins 6 may be attached to said first process unit end 4a of said process unit 4, so that said first process unit end 4a is guided into engagement with said receptor device 1 by means of said one or more process unit mating pins 6 being brought into egagement with said receptor device 1.

Said first process unit end is then entered into said receptor device 1. In order to retain said first process unit end 4a of said process unit 4 safely in position in said receptor device 1, said process unit 4 may be retained in place by means of a lock pin 11, so as to retain said one or more process unit mating pins 6 included in said framework 34 attached to said first process unit end 4a of said process unit 4 in said receptor device 1. Said lock pin 11 can be retained in place and operated in any possible manner, such as being manually operated. However, in a preferred embodiment it is spring loaded and ROV releasable.

After process unit entry in said receptor device 1, said vessel 24 is then positioned so that the weight of said process unit 4 is gradually transferred to said lowering wire 19, so as to start lowering of said second process unit end 4b towards the seabed or said module foundation 12 about said fulcrum formed by said first process unit end 4a engaging said receptor device 1. When the lowering process for said second process unit end 4b has started, said vessel 24 is moved to a position so that an axial force component of the tension generated by said process unit 4 in said lowering wire 19

is directed towards said receptor device 1. The vessel 24 is arranged so that said axial force component is generally parallel with the longitudinal, central axis of said process unit 4; and so that transversal force components of said tension in said lowering wire 19 from said second process unit end 4b of said process unit 4 to said vessel 24 are reduced or minimized.

Thus, said first process unit end 4a is retained in engagement with said receptor device 1, and the risk of disengagement of said first process unit end 4a from said receptor device 1 is reduced or minimized.

After said process unit 4 has been deployed onto the seabed or said module foundation 12, said receptor device 1 may be loosened or removed from said first process unit end 4a of said process unit 4.

A receptor apparatus is also provided with this invention for use in a process unit handling operation, for example as a process unit installation operation as described herein, in which the process unit 4 to be handled comprises a first process unit end 4a and a second process unit end 4b.

Said receptor apparatus includes a receptor device 1 which is arranged for receiving and engaging a first process unit end 4a, and which further is arranged for receiving and engaging said first process unit end 4a of said process unit 4, so as to support the load of said process unit 4, and so as to retain said first process unit end 4a in position in said receptor device 1, thus providing a fulcrum for said first process unit end 4a during handling of said second process unit end 4b.

Said receptor device may be arranged directly on the seabed, but it is preferably arranged on a module foundation 12. A process subsea skid 23, arranged for supporting said receptor device 1 and the load from said process unit 4 may also be arranged on said module foundation 12.

A framework 34 may be attached to said first process unit end 4a of said process unit 4. Said framework 34 may include one or more separator mating pins 6. In such cases, said receptor device 1 may be arranged for receiving said one or more process unit mating pins 6 included in a framework 34 being attached to said first process unit end 4a of said process unit 4. Figs. 1a-1b, 2a-2f, 3a-3d and 5 show a process unit 4 with a framework 34 having one mating pin 6, and figs. 4a-4f and figs. 6a-6c show a process unit having a framework having two mating pins 6.

In one preferred embodiment according to the invention of said receptor apparatus, said receptor device 1 comprises two or more receptor brackets 27 in a spaced apart arrangement, each receptor bracket 27 having a receptor bracket guide 28. Said receptor bracket guides 28 included in said receptor brackets 27 may each be arranged for receiving a process unit mating pin 6 included in said framework 34 attached to said first process unit end 4a, so that said receptor brackets 27 form support bearings for said process unit 4 via said process unit mating pins 6 when engaged with said first process unit end 4a of said process unit 4. Thus, said receptor brackets may form a fulcrum for said first process unit end 4a of said process unit 4. An elastomeric pad 7 may be arranged in connection with each receptor bracket 27 for dampening the impact and the load of said process unit 4.

In a second preferred embodiment according to the invention of said receptor apparatus, said receptor device 1 includes a receptor 1a arranged for receiving and engaging a first process unit end 4a of a process unit 4 and a receptor cylinder 9 in connection with said receptor 1a, said receptor cylinder 9 arranged for receiving and engaging said first process unit end 4b. A receptor dampening or yielding member 8 located in said receptor cylinder 9; said receptor dampening member 8 being arranged for receiving the load of said process unit 4 and for dampening or minimizing the impact of the load of said process unit 4 by said first process unit end 4b on said receptor device 1. Said receptor dampening member 8 can for example be made of an elastomeric material, it can be a piston dampened by water hydraulic, a coil spring, or any other kind of dampening member. A further adequate alternative could be water hydraulic dampening of said separator 4. Said receptor 1a and said receptor cylinder 9 are supported by two or more receptor bearings 2 in a spaced apart arrangement on said module foundation 12. Said receptor bearings 2 are arranged for receiving and supporting the load of said process unit 4, and each receptor bearing 2 is provided with a receptor rotating pin 3 so as to form a fulcrum for said receptor device 1.

Each receptor bearing 2 may also be provided with a dampening pad 7, so as to dampen the impact when said receptor device 1 receives and engages the load of said process unit 4 and for assisting said dampening member 8 in said receptor device 1 in receiving and supporting this load. The dampening pad 7 may, e.g., be made of an elastomeric material.

A restraining device 35 can be provided for maintaining a generally vertical position of said receptor device 1 during entry of said first process unit end 4a of said process unit 4. Said restraining device 35 may be releasable, and is arranged to be released prior to lowering said process unit onto said support arrangement 12a.

In the cases in which a framework 34 having one or more separator pins 6 is attached to said first process unit end 4a of said process unit 4, said receptor 1 and said receptor cylinder 9 may be arranged for receiving said process unit mating pin 6 of said framework 34.

For better guidance and engagement of said process unit 4 with said receptor apparatus, said receptor cylinder 9 can be provided with a rotational guide 10a arranged for engaging a corresponding shoulder 10b on said process unit mating pin 6, so as to facilitate rotation of said process unit mating pin 6 in said receptor cylinder 9 in order to line up said process unit 4 along said module foundation 12.

After landing of process unit 4 on said module foundation 12, one or more, preferably two, pairs of alignment devices 26 may be provided for alignment of said process unit 4 onto said module foundation 12. Subsequently, said process unit 4 may be locked onto said module foundation 12 by means of a locking pin 32

A receptor apparatus according to the invention may be located at the sea-bed, preferably on a module foundation at the seabed, and arranged for facilitating installation of a process unit 4 at the seabed or for retrieval of a process unit from the seabed. It is also possible to locate said receptor apparatus on said transport frame 13 on said vessel 24, said receptor apparatus being arranged for facilitating transport of said process unit 4 to the offshore deployment site, lifting of said process unit 4 into the sea, or for lifting from the sea and transport of said process unit 4 on said vessel 24 to a desired location, such as the shore.

In an embodiment according to the invention in which a receptor apparatus including a receptor device 1 is arranged on said vessel 24, it is preferably arranged for assisting in lifting said process unit 4 from a position in which its longitudinal axis is oriented in a generally horizontal direction on said vessel 24, to a position in which its longitudinal axis is oriented in a generally vertical direction before launch or overboarding of said process unit 4. The preparing and moving step a and launching step may in such cases include the steps described as follows:

- Entering said first process unit end into said receptor device 1 for said first process unit end 4a so that said first process unit end 4a engages said receptor device 1, so as to temporarily form a lower end of said first process unit end 4a.
- Completing said process unit entry in said receptor device 1 and retaining said first process unit end 4a in place in said receptor device 1, so as to form a fulcrum for said first process unit end 4a.
- Lifting said second process unit end 4a while said first process unit end 4a remains supported by said receptor device 1, thus facilitating lifting of said second process unit end 4b so as to bring the longitudinal axis of said process unit 4 to a generally vertical orientation.
- Moving said process unit 4 in said generally vertical orientation to a position in which it is ready to be launched into the sea; and
- Launching said process unit 4 with its longitudinal axis in a generally vertical orientation into the sea.

In this case, said installation method may also include the step of transporting said process unit 4 on said transport frame 13 on said vessel 24 to the offshore site.

There is also provided a method for retrieving an elongate process unit 4 from the seabed, in which said process unit 4 has a first process unit end 4a and a second process unit end 4b. A very general embodiment according to the invention of such a method may comprise the following steps:

a) preparing said process unit 4 for removal from a deployment site;

b) lifting said second process unit end 4b from the seabed or from a module foundation 12 for said process unit 4, said first process unit end 4a being retained in a receptor device 1, thus temporarily forming a lower end of said first process unit end 4a, and so as to bring the longitudinal axis of said process unit 4 to a generally vertical orientation; said first process unit end 4a of said process unit 4 and said receptor device 1 forming a fulcrum for said first process unit end 4a, thus facilitating lifting of said second process unit end 4b;

c) disengaging said first process unit end 4a from said receptor device 1;

d) hauling said process unit 4 from said deployment site at the seabed, up through the sea, the splash zone and the sea surface to a vessel 24;

e) bringing said process unit 4 aboard said vessel 24, and

g) preparing and moving said process unit 4) to a generally horizontal position onboard said vessel, in which it is sea-fastened and ready for being transported on said vessel 24.

Said method may also comprise the step of transporting said process unit 4 onboard said vessel 24 for subsequent lift-off.

A receptor apparatus according to the invention may be used for handling of said first process unit end 4a of said process unit 4 so as to facilitate preparation aboard a vessel 24 for launch of said process unit 4 into the sea, but also for handling of said first process unit end 4a of said process unit 4 so as to facilitate preparation of said process unit 4 aboard a vessel 24 for transport of said process unit 4.

Further, said receptor apparatus according to the invention may be used for handling of said first process unit end 4a of said process unit 4 for deployment of said process unit 4 onto said module foundation 12 arranged at a deployment site at the seabed, but also for handling of said first process unit end 4a of process unit 4 for removal of said process unit 4 from said module foundation 12 arranged at a deployment site at the seabed.

It is possible to use a receptor apparatus according to the invention in an operation for lowering and deploying said process unit 4 onto a deployment site on the seabed. A further possibility is to use of a receptor apparatus according to the invention in an operation for removing and hauling said process unit 4 away from a deployment site at the seabed.

The receptor apparatus with transport frame according to the invention may be attached to the process-unit already in the workshop, where the process unit is manufactured or assembled, and loaded onto a flatbed of a lorry, truck, railway carriage or other wheel carriage. Thereby the unit with transport frame may be transported in one piece from the workshop to the vessel. This will facilitate the handling of the process unit already from the workshop. After retrieval the process-unit with receptor

and transport frame may be loaded onto a lorry, truck, railway carriage or other wheel carriage and transported in one piece back to the workshop for service.

In a preferred embodiment of the invention, the process unit 4 to be handled is a horizontal gravitational separator 4.

Description of a possible embodiment of the invention, in which said process unit is, e.g., a separator

Since the installation or retrieval of a process unit, such as a separator, can become a part of the IMR-scheme for a field, it is important that this operation can be done efficiently with a minimum of down time. There is reason to believe that the maximum allowable operational sea-state for a horizontal deployment will be somewhat limited especially for operations from a monohull.

In order to achieve a controllable operation, a central mating pin 6 has been fixed to the framework 34, for example a framework or separator-skirt 34 located at the first separator end 4a.

For the lift-option the pin is arranged in a guide-funnel which is pivoting in a base structure situated on a common transport skid 13. This skid is sea-fastened on the vessel deck 14.

The separator 4 is resting on cradles 15 on the transport skid 13 and also locked to said skid 13. A pad-eye 33 is arranged on the separator 4 in the opposite end of the mating pin 6. A ROV-shackle 18 with slings from the crane-hook can be connected hereon for the deployment.

For the launching / hauling option the separator may be resting on the vessel deck by means of two launching beams which may be attached to the separator by welding, and further sea-fastened to the vessel deck 14.

Separator overboarding may take place for example by crane or by launching. Figs. 3a-3d relate to the case of crane overboarding. In fig. 3a, the separator 4, resting with its saddles 16 on the cradles 15 located on the transport skid 13 situated on the crane vessel deck 14, is in fig. 3a shown to be ready for upending by the vessel-crane. The skid 13 is sea-fastened while the separator 4 is unlocked from the skid 13. In

fig. 3b, the separator, while still resting in the bearings 2 of the guide-funnel 1, has been rotated about 90 degrees into the vertical position in the bearings 2 under full control by the crane and the guide-funnel 1. When ready to deploy the separator 4, the mating pin 6 is unlocked from the guide-funnel 1 and free to be lifted off by the crane. In fig 3c, the separator is lifted off the guide-funnel 2 and ready to be deployed overboard with the crane. Fig. 3d shows a cross section of the separator in fig. 3a.

By launching:

Reference is now made to figs. 2a-2f and to figs. 4a-4f. An alternative deployment operation can be to launch the separator 4 by, e.g., a 500 ton winch 31 over the stern-roller 29 on the deck 14 of an AHV, as shown in figs. 2a-2b and 4a-4b.

The separator 4 can be fitted with two launch beams 5 similar to what is used for launching large suction anchors of similar size as this separator 4. The separator 4 with the launching beams 5 are sea-fastened to the deck 14 of the vessel 24 during the transport to field.

In addition to the winch lowering wire 19, two launch wires 22 and one launch control wire with bridle 20 and associated auxiliary winches are required in this embodiment of said launching operation.

Fig. 2a and 4a shows the separator 4 rested on deck 14 ready rigged up for launching.

Fig. 2b and 4b shows the separator 4 being launched over the stern roller 29 by means of a set of winches and launch control wires 22 for subsequent deployment to seabed by the separate lowering wire 19. This wire 19 is connected by shackle 18 to the end of the separator and is heave compensated.

In the case in which the receptor apparatus comprises an entry funnel, separator landing on seabed can be made as follows. A similar pivoted guide funnel 1 as on the transport skid 13 is located on the base frame 12,23 subsea. The funnel 1a will be pointing upward prior to mating to receive one or more mating pins 6 on the end of the separator in fig. 2c. The separator 4 is suspended in a preferably heave compensated deployment wire 19 from a crane or winch 31.

A combined operation of vessel 24 and ROV will assist with aligning the mating pin 6 with the funnel 1a with subsequent lowering and entry into the funnel 1

within a 90 degrees sector of the latter, as shown in fig. 2d. An alternative approach is to use two clump weights as proposed for the base frame 12,12a, 23.

The funnel cylinder 9 may be fitted with rotational guides 10a, such as helical groove-slots, which in conjunction with associated control-upsets 10b on the lower end of the mating pin 6 is forcing the separator to twist the necessary angle during the mating in order to align correctly on the base. In the bottom of the funnel-cylinder 9 is located a dampening mechanism 8 which can be of a water hydraulic or elastomeric design, the latter is indicated in the figures.

When landed, the ROV will activate a locking pin locking the separator 4 to the guide funnel 1a. The 90 degrees rotating of the separator onto the process skid 23 can then start by vessel 24 offsetting and lowering of the deployment wire 19 in AHC (active heave compensation) mode.

The separator saddles 16 will then land in the cradles 15 on the skid 23, as shown in figs. 2e and 4e and the shackle 18, which can be a ROV operated shackle, will be disconnected by the ROV.

For proper alignment of the separator one or more, preferably two screw-adjustable wedge-assemblies 26 underneath the separator are activated by the ROV. Elastomeric pads 7 underneath the funnel-bearings 2 will then allow the separator 4 to be aligned as required on the wedges 26. A ROV activated locking pin 32 underneath the separator 4 will then lock it to the process skid 23.

Separator retrieval from seabed can be made as follows. For retrieval of the separator 4 from the process-skid 23, the operation will have to be reverted. After all pipe- and cable-connections have been disconnected by ROV, the ROV-shackle 18 from the crane-hook will then be connected up to the separator 4. The separator is then unlocked and rotated 90 degrees into vertical position by the AHC deployment wire 19. When mating-pin 6 has been released by the ROV, the separator 4 can be retrieved.

The separator 4 can be brought onto vessel deck 14 either by crane or by hauling, for example as follows.

For retrieval of a lift installed separator from the sea onto the deck by crane, the operation as illustrated in figs. 3a-3c will be reverted. Prior to lift the separator 4 out of water the ROV will connect up two tugger lines 30 to the separator to

enable to control it over the deck 14 of the vessel 24 and during entry into the guide-funnel 1.

For retrieval of a launched separator from the sea onto the deck by hauling, the launch operation shown in fig. 2a-2b can be reverted, and the separator 4 with launch beams 5 can be sea fastened to deck 14. The control wire and bridle 20 will be connected and used for the hauling over the stern roller 29 and the lowering wire 19 used for stabilising furing the hauling operation.

Advantages of the invention in IMR (installation module retrieval) operations

The above upending-operation of the separator will provide some additional advantages, thus making the IMR-operations more efficient: the upending of the process unit 4 will give a better opportunity to purge and clear the process unit more efficiently for hydrocarbon gases prior to a retrieval operation. It also provides an improved opportunity for sand removal at the seabed instead of having to retrieve the separator to surface for sand-removal if this is the case.

List of reference numerals

1	receptor device
1a	receptor
2	receptor bearing, e.g., funnel bearing
3	receptor rotating pin, e.g., funnel rotating pin
4	elongate process unit
4a	a first process unit end
4b	a second process unit end
5	launch beam
6	process unit mating pin
7	dampening pad
8	dampening member
8a	dampening member, compressed
8b	dampening member, extended
9	receptor cylinder, e.g., funnel cylinder
10a	rotational guide
10b	guide formation on said process unit mating pin 6 corresponding to rotational guide 10a in said receptor cylinder 9
11	spring loaded lock pin ROV releasable
12	module foundation
13	transport frame
14	vessel deck
15	guide or cradle
16	process unit saddle
17	process unit locking pin/bucket
18	shackle for deployment wire
19	lowering wire
20	launch control-wire bridle
22	launch wire
23	process subsea skid
24	vessel (AHV)
25	snatch-block for launch-wire

26	ROV-adjustable wedge for process unit alignment
27	receptor bracket, e.g., funnel bracket
28	receptor bracket guide, e.g., funnel bracket guide
29	stern roller
30	tugger line
31	vessel crane or vessel winch
32	process unit fastening pin, e.g., process unit locking pin
33	pad-eye
34	framework
35	restraining device
36	vessel wire system
37	heave compensator